Abstract

A voltage source inverter is commonly used to supply a variable frequency variable voltage to a three phase induction motor in a variable speed application The inverter output voltage contains ripple in addition to the required fundamental component Due to this undesired voltage ripple an unwanted ripple current flows, which results in harmonic power loss The voltage ripple also causes ripple in the torque developed in the machine The torque ripple results in speed fluctuations Although these ripple quantities reduce with increase in the average switching frequency of the inverter, the maximum switching frequency is limited by the power handled by the switching devices in the inverter The present work aims at development of a real time pulse width modulation technique to minimize RMS torque ripple for a given switching frequency of the inverter The switching frequency is assumed to be much higher than the fundamental output frequency.

The analysis of torque ripple and current ripple in the drive is carried out in a synchronously revolving d-q frame of reference where the q axis is aligned along the reference voltage vector An analysis in such a frame of reference leads to easy computation of torque ripple, since this ripple is essentially due to the interaction between the steady state flux along the d axis and the ripple current along the q axis It is shown that q axis current ripple, which can be obtained by integrating the q axis error voltage, is proportional to the torque ripple A systematic analytical method is developed for the computation of torque ripple for any real time pulse width modulation technique

Two well known approaches to real time PWM generation are triangle comparison method (TCPWM) and space vector method of PWM generation (SVPWM). Among the TCPWM methods the most common is sine triangle PWM (SPWM). Conventional space vector PWM (CSVPWM) is the most popular SVPWM method. If the neutral of the induction motor is not connected with the mid point of the DC bus then there is a degree of freedom which leads to possible injection of common mode components in the reference signals of the TCPWM This is equivalent to the splitting of the zero vector time between the two zero states in the zero vector split sequences of SVPWM In zero vector split sequences the two active vectors are applied in between the two zero states in a subcycle

The torque ripple is first minimized at a given sampling frequency by choosing an optimal ratio of division of zero vector time leading to the proposed optimal division PWM (ODPWM) It is shown that in this case, minimization of torque ripple also leads to the minimization of current ripple ODPWM leads to a considerable reduction in torque ripple (maximum of 17 %) with a marginal improvement in the current ripple with respect to the CSVPWM along with a fall in average switching frequency at the higher values of reference voltages A simple expression for the optimal ratio of division of zero vector time has been derived leading to easy implementaion in DSP Two hybrid PWM techniques which combine optimal zero vector split sequence with sequences which apply only one zero vector at a higher sampling frequency are proposed The two techniques, namely Minimum Current Ripple Variable Sampling Frequency PWM (MCRVSF PWM) and Minimum Torque Ripple Variable Sampling Frequency PWM (MTRVSF PWM) minimize the current ripple and torque ripple respectively for a given average switching frequency MTRVSF PWM brings about a maximum of 31 % reduction in torque ripple along with a considerable reduction in current ripple (maximum of 30 %), compared to CSVPWM

Active vector split sequences, which have been proposed recently, have also been studied A new space vector based PWM technique called Optimal Division Active PWM (ODAPWM) which employs this kind of sequences, is proposed This brings about a considerable reduction in torque ripple (maximum of 35 %) though with a marginal increase in the current ripple (maximum of 10 %) with respect to CSVPWM A constant sampling frequency hybrid PWM called Minimum Torque Ripple Constant Sampling Frequency PWM (MTRCSF PWM) is proposed in order to improve torque ripple without increasing the current ripple A simple hybrid PWM called Reduced Current Ripple Hybrid PWM (RCRH PWM) is also proposed to reduce current ripple and torque ripple over CSVPWM

Torque ripple and current ripple are predicted analytically, for different existing and proposed PWM techniques Numerical simulation (MATLAB SIMULINK) results confirm the analytical predictions Further, experimental results on a constant v/f drive, consisting of IGBT based inverter, TMS320F2407 DSP based controller and a four pole squirrel cage induction motor, are presented These results confirm the improvement in RMS torque ripple in the drive due to the proposed techniques